

# AN8725FH

## Semiconductor laser power control IC

### Overview

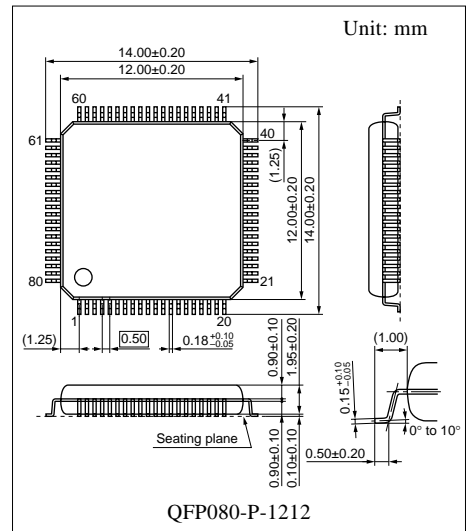
The AN8725FH is a laser driver IC that can set a laser emitting level to a maximum precision in recording and playback of an optical recording equipment such as PD, and can modulate a laser light in tune with the external signal.

### Features

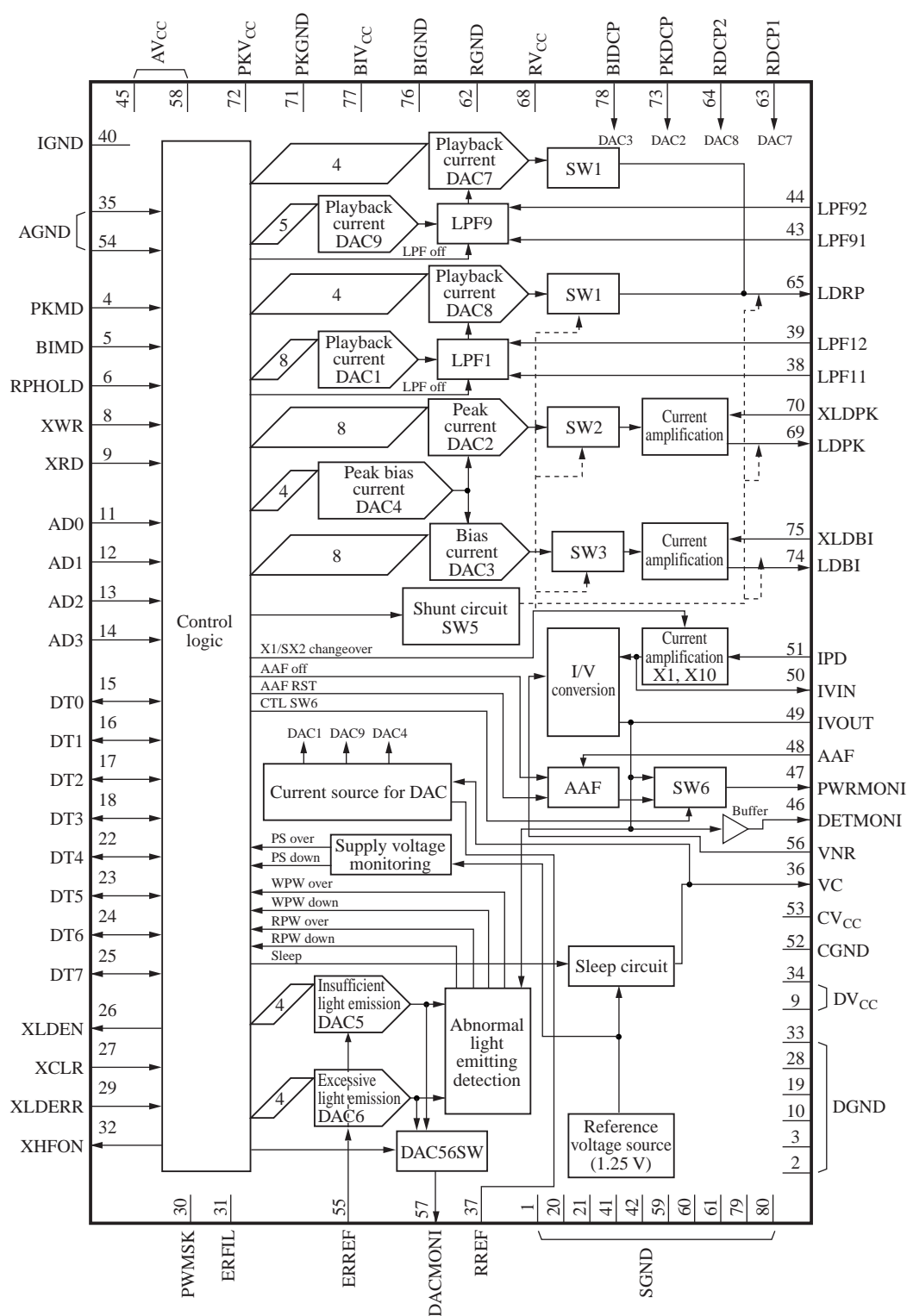
- Digital setting of playback current, peak current, bias current and abnormal light emitting level
- Peak current and bias current can be modulated by the external signal.
- Driving current set-up (digital set-up)
  - For playback: 8-bit + 4-bit (0 mA to 80 mA)
  - 5-bit + 4-bit (0 mA to 150 mA)
  - For peak: 4-bit + 8-bit (0 mA to 150 mA)
  - For bias: 4-bit + 8-bit (0 mA to 150 mA)
- Laser output light monitoring circuit built-in
- Abnormal light emitting detecting function built-in:
  - Possible to set up excessive and insufficient light emitting levels with 4-bit DAC for playback and recording, respectively.
- Supply voltage abnormality detection:
  - Voltage down (3.9 V or less), voltage up (6.1 V or more)

### Applications

- Optical disk drive



# ■ Block Diagram



## ■ Pin Descriptions

Note) Description on notations of "Category" in the following list:

IN : Input pin

I/O : Input/output pin (pull-down with 100 kΩ)

IND : Input pin (pull-down with 100 kΩ)

PS : Power supply/GND pin

INU : Input pin (pull-up with 100 kΩ)

MSC : Parts connecting pin, etc.

OUT: Output pin

A: Analog function

D: Digital function

Pin No.	Symbol	Category		Description
1	SGND	PS	D	Pin connected to the chip substrate. Must be used in the same potential as other GND pins.
2	DGND	PS	D	GND pin exclusive for a logic circuit. Must be used in the same potential as other GND pins.
3	DGND	PS	D	
4	PKMD	IND	D	Peak current modulation signal input pin. In high-level, the current set up with DAC2 is superimposed on LD.
5	BIMD	IND	D	Bias current modulation signal input pin. In high-level, the current set up with DAC3 is superimposed on LD.
6	RPHOLD	IND	D	Record gate signal input pin. Inputs a low-level in playback and a high-level in recording. Switches an amp. of light monitoring signal, abnormally emitted light detection level and on/off of HF module.
7	XWR	INU	D	Register writing signal pin. Selects a register specified by address in a fall edge and writes a bus data on the register of the address specified in the rise edge.
8	XRD	INU	D	Register read-out signal pin. Register data of the address specified in low appears on the bus.
9	DV <sub>CC</sub>	PS	D	Power supply pin exclusive for a logic circuit. Must be used in the same potential as other power supply pins.
10	DGND	PS	D	GND pin exclusive for a logic circuit. Must be used in the same potential as other GND pins.
11	AD0	IND	D	4-bit address pin for registers. Selects the register to be accessed.
12	AD1	IND	D	
13	AD2	IND	D	
14	AD3	IND	D	
15	DT0	I/O	D	Data I/O 8-bit bus pin. The bus to set the data to be written on a register and to read out the data of a register.
16	DT1	I/O	D	
17	DT2	I/O	D	
18	DT3	I/O	D	
19	DGND	PS	D	GND pin exclusive for a logic circuit. Must be used in the same potential as other GND pins.

## ■ Pin Descriptions (continued)

Pin No.	Symbol	Category		Description
20	SGND	PS	D	Pin connected to the chip substrate.
21	SGND	PS	D	Must be used in the same potential as other GND pins.
22	DT 4	I/O	D	Data I/O 8-bit bus pin.
23	DT 5	I/O	D	The bus to set the data to be written on a register and to read out the data of a register.
24	DT 6	I/O	D	
25	DT 7	I/O	D	
26	XLDEN	INU	D	LD enable input pin. In a high-level or open mode, LD becomes off and open. This state is suited to check the LD characteristics in keeping a connection to the IC. At the time power off, both ends of LD are short-circuited by the IC for protection. In the low-level, it returns to a normal operation.
27	XCLR	IND	D	Clear signal input pin. Sets an LDDENB register to "0" in the low-level and presets the status of each DAC and each switch to an initial state as defined separately. But six registers for an abnormal detection are not cleared. In this state, each output of a current amplification 1, 2, 3 are in the off state and a shunt circuit becomes on to continue to protect LD. Setting this pin to the high-level and the LDDENB register to "1", it returns to a normal operation.
28	DGND	PS	D	GND pin exclusive for a logic circuit. Must be used in the same potential as other GND pins.
29	XLDERR	OUT	D	Laser abnormality detection output pin. When a supply voltage or a laser light emission exceeds a fixed range, it goes to low-level. A supply voltage abnormality is detected for the voltage drop (3.9 V or less) or voltage rise (6.1 V or more). And an abnormal light emission is detected for an excessive or weaker light emission set up by 4-bit DAC5 and DAC6. This abnormality detection is latched so as to prevent it from being reset until ERRCLR register is set to "1". Further, each DAC output of a playback current, a peak current and a bias current can be set to off, a shunt circuit be set to on and LD between anode and GND be short-circuited by 100 $\Omega$ so that LD can be protected. This protection function is latched to keep it from being reset until ERRCLR is set to "1". Selection of either operation or non-operation for this operation can be made by an STPMSK register.
30	PWMSK	MSC	D	The pin to set up the mask time for a transitional response output that comes out at switching a detection level of excessive or insufficient light emission by RPHOLD. Set a mask time by an external capacitor between PWMSK and DGND and the resistor (10 k $\Omega$ ) inside the IC. This pin is for a schmitt-trigger input.

## ■ Pin Descriptions (continued)

Pin No.	Symbol	Category		Description
31	ERFIL	MSC	D	Filter setting pin to avoid a detection error of laser abnormality caused by noise. Connect an external capacitor between ERFIL and DGND, and set a filter together with a resistor (10 k $\Omega$ ) inside the IC. This pin is for schmitt-trigger input.
32	XHFON	OUT	D	HF module on/off control signal output pin. High corresponds to off and low to on.
33	DGND	PS	D	GND pin exclusive to a logic circuit. Must be used in the same potential as other GND pins.
34	DV <sub>CC</sub>	PS	D	Power supply pin exclusive to a logic circuit. Must be used in the same potential as other power supply pins.
35	AGND	PS	A	GND pin exclusive to an analog circuit. Must be used in the same potential as other GND pins.
36	VC	MSC	A	Output pin for reference voltage (1.25 V). Connects a capacitor C between this pin and AGND for de-coupling.
37	RREF	MSC	A	Reference resistor connecting pin to determine an output current for each DAC. Connect a resistor of 10 k $\Omega$ between RREF and AGND.
38	LPF11	MSC	A	LPF characteristic setting pin for DAC1 and DAC8. Connect an external resistor between LPF11 and LPF12, and then capacitor between LPF12 and IGND to set up a cutoff frequency.
39	LPF12	MSC	A	
40	IGND	PS	A	GND pin for playback power supply setting DAC1, DAC9 and disturbance reduction LPF. Must be used in the same potential as other GND pins.
41	SGND	PS	D	Pin connected to the chip substrate. Must be used in the same potential as other GND pins.
42	SGND	PS	D	
43	LPF91	MSC	A	LPF characteristic setting pin for DAC9 and DAC7. Connect an external resistor between LPF91 and LPF92 and then capacitor between LPF92 and IGND to set a cutoff frequency.
44	LPF92	MSC	A	
45	AV <sub>CC</sub>	PS	A	Power supply pin for an analog circuit, a reference supply voltage circuit, etc. Must be used in the same potential as other power supply pins.
46	DETMONI	OUT	A	Pin to monitor a signal for detecting abnormally emitted light. In a playback mode, the signal output is five times that in recording (ten times is possible by a register setting). Has offset to VNR due to being outputted through a buffer of transistors.
47	PWRMONI	OUT	A	Laser emitting light monitor signal. In a low-level of RPHOLD, the amplifier output has 10 times gain compared with recording, and is equipped with AFF.

## ■ Pin Descriptions (continued)

Pin No.	Symbol	Category		Description
48	AAF	MSC	A	AAF characteristic setting pin for optical monitor circuit. Connect an external resistor, capacitor between AAF and IVOUT and set up a cutoff frequency.
49	IVOUT	OUT	A	I to V conversion signal output pin. Connect an external variable resistor between IVIN and IVOUT.
50	IVIN	MSC	A	I to V conversion resistor connection pin. Connect an external variable resistor between IVIN and IVOUT.
51	IPD	MSC	A	Pin photo diode (PD) connection pin. Connect a pin photo diode for detecting a semiconductor laser emitting light. Connect anode to this pin. Applicable to a source-type PD which has a typical value of 40 $\mu$ A to 160 $\mu$ A output in object lens output power of 1 mW.
52	CGND	PS	A	GND pin in an optical monitor circuit. Must be used in the same potential as other GND pins.
53	CV <sub>CC</sub>	PS	A	Power supply pin in an optical monitor circuit. Must be used in the same potential as other power supply pins.
54	AGND	PS	A	GND pin exclusive to a analog circuit. Must be used in the same potential as other GND pins.
55	ERREF	IN	A	Abnormally emitting light detecting range setting pin. Sets a full scale voltage of DAC5 and DAC6. A setting range is VNR or more and input range of an external ADC or less.
56	VNR	IN	A	Reference level input pin for PWRMONI output. Input a reference voltage of 1.25 V of an external ADC.
57	DACMONI	OUT	A	DAC5, DAC6 monitor pin. DAC5 voltage is outputted when DAC56 SW register is low, DAC6 voltage is outputted when DAC6 voltage is high.
58	AV <sub>CC</sub>	PS	A	Power supply pin for an analog circuit, a reference supply voltage circuit, etc. Must be used in the same potential as other power supply pins.
59	SGND	PS	D	Pin connected to the chip substrate. Must be used in the same potential as other GND pins.
60	SGND	PS	D	
61	SGND	PS	D	
62	RGND	PS	A	GND pin for the lead current setting DAC7 and DAC8. Must be used in the same potential as other GND pins.
63	RDCP1	MSC	A	Pin to connect a de-coupling capacitor to protect the output current of DAC7, the read current setting circuit, from disturbance by a switching noise such as peak current. (Connects a capacitor between RDCP1 and RGND.)

## ■ Pin Descriptions (continued)

Pin No.	Symbol	Category		Description
64	RDCP2	MSC	A	Pin to connect a de-coupling capacitor to protect the output current of DAC7, the read current setting circuit, from disturbance by a switching noise such as peak current. (Connects a capacitor between RDCP2 and RGND.)
65	LDRP	OUT	A	Source type read current (DAC1, DAC7, DAC8, DAC9) output pin. Possible to set up the range of 0 mA to 150 mA in the precision of 8-bit + 4-bit + 5-bit + 4-bit. Output voltage range is 1.0 V to 3.5 V.
66	N.C.	—	—	N.C. pin.
67	N.C.	—	—	Open the pin or connect to GND.
68	RV <sub>CC</sub>	PS	A	Power supply pin for read current setting DAC7, DAC8. Consumes approximately a quarter of the necessary read current. Must be used in the same potential as other power supply pins.
69	LDPK	OUT	A	Source-type peak current (DAC2) output pin. Possible to set the range of 0 mA to 150 mA in the accuracy of 8-bit. The output voltage range is 1.0 V to 3.2 V.
70	XLDPK	IN	A	Sink-type peak current output pin. Approximately three fourths of LDRK output current are outputted from this pin.
71	PKGND	PS	A	GND pin of DAC2 in the peak current setting circuit. Must be used in the same potential as other GND pins.
72	PKV <sub>CC</sub>	PS	A	DAC2 power supply pin in the peak current setting circuit. Consumes approximately a quarter of the setting current. Must be used in the same potential as other power supply pins.
73	PKDCP	MSC	A	Pin to connect a de-coupling capacitor to avoid the output current disturbance, which is caused by a switching noise such as peak current, in peak current setting circuit DAC2. (Connects a capacitor between PKDCP and PKGND.)
74	LDBI	OUT	A	Source-type bias current (DAC3) output pin. Possible to set the range of 0 mA to 150 mA in the accuracy of 8-bit. Output voltage range is 1.0 V to 3.2 V.
75	XLDBI	IN	A	Sink-type peak current output pin. Approximately three fourths of LDBI output current are outputted from this pin.
76	BIGND	PS	A	GND pin of a bias current setting circuit DAC3. Must be used in the same potential as other GND pins.
77	BIV <sub>CC</sub>	PS	A	Power supply pin of a bias current setting circuit DAC3. Consumes approximately one fourth of a setting current. Must be used in the same potential as other power supply pins.

## ■ Pin Descriptions (continued)

Pin No.	Symbol	Category		Description
78	BIDCP	MSC	A	Pin to connect a de-coupling capacitor to avoid the output current disturbance, which is caused by a switching noise such as bias current, of a bias current setting circuit DAC3. (Connects a capacitor between BIDCP and BIGND.)
79	SGND	PS	D	Pin connected to the chip substrate.
80	SGND	PS	D	Must be used in the same potential as other GND pins.

## ■ Absolute Maximum Ratings

Parameter	Symbol	Rating	Unit
Supply voltage	$V_{CC}$	7.0	V
Input voltage	$V_{IN}$	- 0.4 to $V_{CC} + 0.4$	V
Output voltage	$V_{OUT}$	- 0.4 to $V_{CC} + 0.4$	V
Parts connecting pin voltage	$V_{MSC}$	- 0.4 to $V_{CC} + 0.4$	V
Supply current	$I_{CC}$	80	mA
Pin current	$I_{PIN}$	-100 to +100	mA
Power dissipation *2	$P_D$	600	mW
Operating ambient temperature *1	$T_{opr}$	-20 to +75	°C
Storage temperature *1	$T_{stg}$	-55 to +150	°C

Note) \*1: Except for the operating ambient temperature and storage temperature, all ratings are for  $T_a = 25^\circ\text{C}$ .

\*2: The power dissipation shown is for the IC package in single unit at  $T_a = 75^\circ\text{C}$ .

Refer to "■ Application Notes, 1.  $P_D$  —  $T_a$  curves of QFP080-P-1212".

## ■ Recommended Operating Range

Parameter	Symbol	Range	Unit
Supply voltage	$V_{CC}$	4.50 to 5.50	V

## ■ Electrical Characteristics at $V_{CC} = 5.0\text{ V}$ , $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply current						
Supply current	$I_{CC}$	XCLR = low, digital I/O pin = open, $I_{PD} = 0\text{ }\mu\text{A}$	—	20	30	mA
Sleep mode supply current	$I_{SLP}$	Sleep = 1, $I_{PD} = 0\text{ }\mu\text{A}$	—	3	4	mA
Reference voltage block						
Reference voltage output	$V_{REF}$		1.20	1.25	1.30	V
Reference voltage variation	$\Delta V_{REF}$	$V_{CC} = 4.5\text{ V to }5.5\text{ V}$ , $I_{REF} = 0\text{ mA}$	—	—	$\pm 15$	mV
		$V_{CC} = 4.5\text{ V to }5.5\text{ V}$ $I_{REF} = -1\text{ mA to }+1\text{ mA}$	—	—	$\pm 20$	
Maximum output current	$\Delta V_{OM}$	$I_{REF} = -1.5\text{ mA}$ , difference from $I_{REF} = 0\text{ mA}$	—	—	$\pm 50$	mV



■ Electrical Characteristics at  $V_{CC} = 5.0 \text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Digital block						
High-level input voltage	V <sub>IH</sub>	To be applied to a digital input pin	0.8 × V <sub>CC</sub>	—	—	V
Low-level input voltage	V <sub>IL</sub>	To be applied to a digital input pin	—	—	0.2 × V <sub>CC</sub>	V
High-level input voltage (Schmitt-trigger input)	V <sub>IHSHC</sub>	To be applied to PWMSK, ERFIL pin	0.8 × V <sub>CC</sub>	—	—	V
Low-level input voltage (Schmitt-trigger input)	V <sub>ILSHC</sub>	To be applied to PWMSK, ERFIL pin	—	—	0.2 × V <sub>CC</sub>	V
High-level output voltage	V <sub>OH</sub>	I <sub>OH</sub> = −2 mA	0.8 × V <sub>CC</sub>	—	—	V
Low-level output voltage	V <sub>OL1</sub>	I <sub>OL</sub> = +2 mA	—	—	0.2 × V <sub>CC</sub>	V
	V <sub>OL2</sub>	I <sub>OL</sub> = +0.5 mA	—	—	0.4	
Input pull-up, pull-down resistance	R <sub>PD</sub>	Pull-up: V <sub>IL</sub> = 0 V Pull-down: V <sub>IH</sub> = 5.0 V	75	100	125	kΩ
Input leak	I <sub>LKH</sub>	To be applied to a digital input pin, V <sub>OH</sub> = 5.25 V	—	—	80	μA
	I <sub>LKL</sub>	To be applied to a digital input pin, V <sub>OL</sub> = 0 V	—	—	10	
Entire optical monitor						
Offset voltage at playback	V <sub>PMOFR</sub>	VR1 = 1 kΩ, I <sub>PD</sub> = 0 mA	−15	—	15	mV
		VR1 = 1 kΩ, difference from an ideal value at I <sub>PD</sub> = 100 μA to 200 μA	−40	0	40	
Offset voltage at recording	V <sub>PMOFW</sub>	VR1 = 1 kΩ, I <sub>PD</sub> = 0 mA	−15	—	15	mV
		VR1 = 1 kΩ, difference from an ideal value at I <sub>PD</sub> = 100 μA to 2 000 μA	−20	0	20	
Gain ratio	GR	G <sub>PMR</sub> /G <sub>PMW</sub> , output = VNR +0.6 V to 2.0 V	9.0	10.0	11.0	times
Maximum output voltage	V <sub>PM max</sub>		V <sub>CC</sub> × 0.73	V <sub>CC</sub> × 0.78	—	V
Minimum output voltage	V <sub>PM min</sub>		—	—	VNR−0.015	V
f characteristics at playback	f <sub>PMR AAF OFF</sub>	AAF-off VR1 = 1 kΩ, −3 dB, I <sub>PD</sub> = 100 μA to 200 μA	4	6	—	MHz
f characteristics at recording	f <sub>PMW</sub>	VR1 = 1 kΩ, −3 dB, I <sub>PD</sub> = 100 μA to 2 000 μA	6	7.5	—	MHz
Settling time at playback	t <sub>PMSETR</sub>	VR1 = 1 kΩ, error ±0.5%, output variation: Range of 0 V to 2 V	—	200	400	ns
Settling time at recording	t <sub>PMSETW</sub>	VR1 = 1 kΩ, error ±0.5%, output variation: Range of 0 V to 2 V	—	200	400	ns

■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Current amplification changeover						
Gain at playback	$G_{IPDR}$	Reg7 = "80h", $I_{PD} = 40\text{ }\mu\text{A}$ to $240\text{ }\mu\text{A}$	9.0	10.0	11.0	times
Gain at recording	$G_{IPDW}$	Reg7 = "C0h", $I_{PD} = 200\text{ }\mu\text{A}$ to $3\text{ }200\text{ }\mu\text{A}$	0.9	1.0	1.1	times
Gain ratio	$GR_{IPD}$	$G_{IPDR}/G_{IPDW}$	9.0	10.0	11.0	times
I to V conversion block						
Offset voltage	$V_{IVOF}$	$VR1 = 0\text{ }\Omega$ , $I_{PD} = 0\text{ mA}$	-15	—	15	mV
DAC1 block						
Resolution	RES1		—	8	—	bit
Integral linearity error	EL1		-1.0	—	10.0	LSB
Differential linearity error	ED1		-1.0	—	1.5	LSB
Maximum output current	$I_{1max}$	DAC1 = "FFh", DAC8 [Fh], DAC7 [0h], DAC9 [00h]	70	80	90	mA
Offset current	$I_{1OF1}$	"00h" LPF-on, DAC8 [Fh], DAC7 [0h], DAC9 [00h], DAC7, DAC8 characteristics included	-1	—	1	mA
	$I_{1OF2}$	"00h" LPF-off, DAC8 [Fh], DAC7 [0h], DAC9 [00h]	-250	—	250	$\mu\text{A}$
LPF on/off gain ratio	$GR_{DAL}$	$G_{LPPFON}/G_{LPPFOFF}$ , input amplitude 0 V to 2 V	0.95	1	1.05	times
Settling time	$t_{SDA1}$	XWR $\uparrow$ to DAC1 [10h to 8Fh], $\pm 2$ LSB range, DAC7 [0h], DAC8 [Fh], DAC9 [00h] LPF-off, LPF11 pin open, RDCP2 pin open	—	400	800	ns
DAC7 block						
Resolution	RES7		—	4	—	bit
Integral linearity error	EL7		-1.0	—	1.0	LSB
Differential linearity error	ED7		-0.5	—	0.5	LSB
Maximum output current	$I_{7max}$	Set to DAC7 = "Fh", DAC9 [1Fh], DAC1 [00h], DAC8 [0h]	133	150	170	mA
Minimum output current	$I_{7min}$	Set to DAC7 = "0h", DAC9 [1Fh], DAC1 [00h], DAC8 [0h]	-0.1	0	0.1	mA
Settling time	$t_{SDA7}$	XWR $\uparrow$ to DAC7 [0h to Fh], DAC9 [1Fh], $\pm 0.5$ LSB, DAC1 [00h], DAC8 [0h]	—	50	500	ns
DAC8 block						
Resolution	RES8		—	4	—	bit
Integral linearity error	EL8		-1.0	—	1.0	LSB
Differential linearity error	ED8		-0.5	—	0.5	LSB

■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
DAC8 block (continued)						
Maximum output current	$I_{8\max}$	Set to DAC8 = "Fh", DAC1 [FFh], DAC9 [1Fh], DAC7 [0h]	70	80	90	mA
Minimum output current	$I_{8\min}$	Set to DAC8 = "0h", DAC1 [FFh], DAC9 [1Fh], DAC7 [0h]	4	5	6	mA
Settling time	$t_{\text{SDA8}}$	XWR $\uparrow$ to DAC8 [0h to Fh], DAC1 [80h], $\pm 0.5$ LSB, DAC9 [00h], DAC7 [0h]	—	50	250	ns
DAC2 block						
Resolution	RES2		—	8	—	bit
Integral linearity error	EL2		−1.0	—	5.0	LSB
Differential linearity error	ED2		−1.0	—	1.0	LSB
Maximum output current	$I_{2\max}$	DAC2 = "FFh", DAC4 [Fh]	133	150	170	mA
Offset current	$I_{2\text{OF}}$	DAC2 = "00h", DAC4 [Fh]	− 0.1	—	0.1	mA
Settling time	$t_{\text{SDA2}}$	XWR $\uparrow$ to DAC2 [10h to FFh], $\pm 2.0$ LSB, DAC4 [Fh]	—	100	250	ns
DAC3 block						
Resolution	RES3		—	8	—	bit
Integral linearity error	EL3		−1.0	—	5.0	LSB
Differential linearity error	ED3		−1.0	—	1.0	LSB
Maximum output current	$I_{3\max}$	DAC3 = "FFh", DAC4 [Fh]	133	150	170	mA
Offset current	$I_{3\text{OF}}$	DAC3 = "00h", DAC4 [Fh]	− 0.1	—	0.1	mA
Settling time	$t_{\text{SDA3}}$	XWR $\uparrow$ to DAC3 [10h to FFh], $\pm 2.0$ LSB, DAC4 [Fh]	—	200	450	ns
DAC4 block						
Resolution	RES4		—	4	—	bit
Integral linearity error	EL4		−1.0	—	1.0	LSB
Differential linearity error	ED4		−1.0	—	1.0	LSB
Maximum output current	$I_{4\max}$	DAC2 = "FFh", DAC4 [Fh]	133	150	170	mA
Offset current	$I_{4\text{OF}}$	DAC2 = "00h", DAC4 [Fh]	− 0.1	—	0.1	mA
Settling time	$t_{\text{SDA4}}$	XWR $\uparrow$ to DAC4 [0h to Fh], $\pm 0.5$ LSB, DAC2 [FFh]	—	300	600	ns
DAC9 block						
Resolution	RES9		—	5	—	bit
Integral linearity error	EL9		−1.0	—	1.0	LSB
Differential linearity error	ED9		−1.0	—	1.0	LSB
Maximum output current	$I_{9\max}$	DAC9 = "1Fh", DAC7 [Fh], DAC1 [00h], DAC8 [0h]	133	150	170	mA

**■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)**

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
DAC9 block (continued)						
Offset current	I <sub>9OF1</sub>	"00h" LPF-on, DAC7 [Fh], DAC8 [0h], DAC1 [00h], DAC7, DAC8 characteristics included	−2.0	—	2.0	mA
	I <sub>9OF2</sub>	"00h" LPF-off, DAC7 [Fh], DAC8 [0h], DAC9 [00h], DAC7, DAC8 characteristics included	− 0.85	—	0.85	
LPF on/off gain ratio	GR <sub>DA9</sub>	G <sub>LPFON</sub> /G <sub>LPFOFF</sub> , input amplitude 0 V to 2 V	0.95	1	1.05	times
Settling time	t <sub>SDA9</sub>	XWR ↑ to DAC9 [00h to 1Fh] ±2 LSB range, DAC7[Fh], DAC8 [0h], LPF9-off, LPF91 pin open, RDCP1 pin open	—	400	800	ns
Supply voltage monitoring block						
Abnormality release supply voltage	V <sub>PSDL</sub>	Sweep V <sub>CC</sub> from low to high	3.9	4.2	4.5	V
	V <sub>PSOL</sub>	Sweep V <sub>CC</sub> from high to low	5.5	5.8	6.1	
Abnormality supply voltage	V <sub>PSDH</sub>	Sweep V <sub>CC</sub> from high to low	3.6	3.9	4.2	V
	V <sub>PSOH</sub>	Sweep V <sub>CC</sub> from low to high	5.8	6.1	6.4	
Abnormally emitted light detection DAC5						
Resolution	RES5		—	4	—	bit
Integral linearity error	EL5		− 0.5	—	0.5	LSB
Differential linearity error	ED5		− 0.5	—	0.5	LSB
Offset voltage	V <sub>5OF1</sub>	DAC5 = set to "Fh" and difference to ERREF pin	−20	—	20	mV
	V <sub>5OF2</sub>	DAC5 = set to "0h" and difference to VNR pin, at ERREF − VNR = 2.0 V	105	125	145	
Settling time	t <sub>SDA5</sub>	XWR ↑ to DAC5 [0h to Fh], ±0.5 LSB	—	0.5	1.5	μs
Abnormally emitted light detection DAC6						
Resolution	RES6		—	4	—	bit
Integral linearity error	EL6		− 0.5	—	0.5	LSB
Differential linearity error	ED6		− 0.5	—	0.5	LSB
Offset voltage	V <sub>6OF1</sub>	DAC6 = set to "Fh" and difference to ERREF pin	−20	—	20	mV
	V <sub>6OF2</sub>	DAC6 = set to "0h" and difference to VNR pin, at ERREF − VNR = 2.0 V	105	125	145	
Settling time	t <sub>SDA6</sub>	XWR ↑ to DAC6 [0h to Fh] ±0.5 LSB	—	0.5	1.5	μs

■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Abnormally emitted light detection optical monitor block						
Offset voltage	$V_{\text{EROFR}}$	In playback, DETMONI pin, $I_{\text{PD}} = 0\text{ }\mu\text{A}$	-40	—	60	mV
	$V_{\text{EROFW}}$	In recording, DETMONI pin, $I_{\text{PD}} = 0\text{ }\mu\text{A}$	-50	—	50	
Gain	$G_{\text{ERR1}}$	In playback, addr. "9": D4 = "0", $I_{\text{PD}} = 100\text{ }\mu\text{A}$ to $200\text{ }\mu\text{A}$	9.0	10.0	11.0	times
	$G_{\text{ERR2}}$	In playback, addr. "9": D4 = "1", $I_{\text{PD}} = 100\text{ }\mu\text{A}$ to $200\text{ }\mu\text{A}$	4.5	5.0	5.5	
	$G_{\text{ERW}}$	In recording, DETMONI pin, $I_{\text{PD}} = 100\text{ }\mu\text{A}$ to $2\text{ }000\text{ }\mu\text{A}$	0.9	1.0	1.1	
Gain ratio	$\frac{G_{\text{ERR1}}}{G_{\text{ERW}}}$		9.0	10.0	11.0	times
	$\frac{G_{\text{ERR2}}}{G_{\text{ERW}}}$		4.5	5.0	5.5	
f characteristics at playback	$f_{\text{ERR}}$	$\text{VR1} = 1\text{ k}\Omega$ , -3 dB, $I_{\text{PD}} = 100\text{ }\mu\text{A}$ to $200\text{ }\mu\text{A}$	2.5	—	—	MHz
f characteristics at recording	$f_{\text{ERW}}$	$\text{VR1} = 1\text{ k}\Omega$ , -3 dB, $I_{\text{PD}} = 100\text{ }\mu\text{A}$ to $2\text{ }000\text{ }\mu\text{A}$	5.0	—	—	MHz
Control operation response						
Data write to XLDERR ↓	$t_{203}$	XWR ↑ to XLDERR ↓	—	20	60	ns
Data write to XLDERR ↑	$t_{204}$	XWR ↑ to XLDERR ↑	—	25	60	ns
Data write to sleep mode	$t_{205}$	XWR ↑ to sleep mode	—	4	9	$\mu\text{s}$
Data write to normal mode	$t_{206}$	XWR ↑ to normal mode	—	3	8	$\mu\text{s}$
RPHOLD ↑ to DAC5 R → W	$t_{39}$	RPHOLD ↑ to DAC5 W, at having reached $\pm 0.5\text{ LSB}$	—	0.40	2.5	$\mu\text{s}$
RPHOLD ↓ to DAC5 W → R	$t_{40}$	RPHOLD ↓ to DAC5 R, at having reached $\pm 0.5\text{ LSB}$	—	0.40	2.5	$\mu\text{s}$
RPHOLD ↑ to DAC6 R → W	$t_{41}$	RPHOLD ↑ to DAC6 W, at having reached $\pm 0.5\text{ LSB}$	—	0.40	2.5	$\mu\text{s}$
RPHOLD ↓ to DAC6 W → R	$t_{42}$	RPHOLD ↓ to DAC6 R, at having reached $\pm 0.5\text{ LSB}$	—	0.40	2.5	$\mu\text{s}$
RPHOLD ↑ to HF module signal	$t_{43}$	RPHOLD ↑ to XHFON ↑	—	18	30	ns
RPHOLD ↓ to HF module signal	$t_{44}$	RPHOLD ↓ to XHFON ↓	—	17	30	ns

■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Recording Modulation						
Peak modulation signal response *1	$t_{113}$	PKMD $\uparrow$ to LDPK $\uparrow$ 50% delay	—	18	30	ns
	$t_{114}$	PKMD $\downarrow$ to LDPK $\downarrow$ 50% delay	—	17	30	
	$t_{115}$	LDPK $\uparrow$ 50% to LDPK $\downarrow$ 50%	$t_{112} - 3$	$t_{112} - 1$	$t_{112} + 1$	
	$t_{116}$	LDPK $\uparrow$ 10% to LDPK $\uparrow$ 90%	—	6	9	
	$t_{117}$	LDPK $\downarrow$ 90% to LDPK $\downarrow$ 10%	—	4	6	
Bias modulation signal response *1	$t_{123}$	BIMD $\uparrow$ to LDBI $\uparrow$ 50% delay	—	18	30	ns
	$t_{124}$	BIMD $\downarrow$ to LDBI $\downarrow$ 50% delay	—	17	30	
	$t_{125}$	LDBI $\uparrow$ 50% to LDBI $\downarrow$ 50%	$t_{122} - 3$	$t_{122} - 1$	$t_{122} + 1$	
	$t_{126}$	LDBI $\uparrow$ 10% to LDBI $\uparrow$ 90%	—	6	9	
	$t_{127}$	LDBI $\downarrow$ 90% to LDBI $\downarrow$ 10%	—	5	8	

Note) \*1: Resistive load (at  $15\ \Omega$ )

Conditions of  $t_{113}$  to  $t_{117}$

Measure at approximately 1.75 V of LDPK pin voltage.

DAC1 [FFh], DAC8 [7h]

DAC9 [1Fh], DAC7 [7h], DAC4 [Fh]

DAC2 [00h to 80f]

Conditions of  $t_{123}$  to  $t_{127}$

Measure at approximately 1.75 V of LDPK pin voltage.

DAC1 [FFh], DAC8 [7h]

DAC9 [1Fh], DAC7 [7h], DAC4 [Fh]

DAC3 [00h to 80f]

• Design reference data

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Reference voltage block						
Reference voltage temperature characteristics *2	$\Delta V_{TEM}$	$V_{REF} = 0\text{ V}$ , $T_a = -20^\circ\text{C}$ to $+75^\circ\text{C}$	—	—	$\pm 30$	mV
Digital block						
Low $\rightarrow$ high input hysteresis (Schmidt trigger input)	$V_{LHHYS}$	To be applied to PWMSK, ERFIL pin	—	1.0	—	V
High $\rightarrow$ low input hysteresis (Schmidt trigger input)	$V_{HLHYS}$	To be applied to PWMSK, ERFIL pin	—	1.0	—	V
Entire optical monitor						
Offset voltage temperature variation	$\frac{\Delta V_{PMOFR}}{\Delta T}$	In playback, $VR1 = 1\text{ k}\Omega$ $I_{PD} = 10\ \mu\text{A}$ to $200\ \mu\text{A}$ $T_a = -20^\circ\text{C}$ to $+75^\circ\text{C}$	—	55	200	$\frac{\mu\text{V}}{^\circ\text{C}}$
	$\frac{\Delta V_{PMOFW}}{\Delta T}$	In recording, $VR1 = 1\text{ k}\Omega$ $I_{PD} = 100\ \mu\text{A}$ to $2\ 000\ \mu\text{A}$ $T_a = -20^\circ\text{C}$ to $+75^\circ\text{C}$	—	30	150	

Note) \*2: Difference between  $V_{REF}$  min. and  $V_{REF}$  max. within the range of  $T_a = -20^\circ\text{C}$  to  $+75^\circ\text{C}$ .

# ■ Electrical Characteristics at $V_{CC} = 5.0\text{ V}$ , $T_a = 25^\circ\text{C}$ (continued)

## • Design reference data (continued)

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Entire optical monitor (continued)						
Gain ratio variation to temperature	$d\frac{G_{PMR}}{G_{PMW}}$	$T_a = -20^{\circ}\text{C}$ to $+75^{\circ}\text{C}$	-3	—	3	%
Slew rate	$SI_{PMR}$	In playback, AAF-off rise	13	18	—	V/ $\mu\text{s}$
	$SI_{PMW}$	In recording, rise	35	45	—	
Signal changeover response	$t_{PMSW1}$	$\times 10 \rightarrow \times 1$ , at having reached $\pm 0.5\%$	—	100	300	ns
	$t_{PMSW2}$	$\times 1 \rightarrow \times 10$ , at having reached $\pm 0.5\%$	—	200	500	
f characteristics	$f_{PMROF}$	In playback, -3 dB, $VR1 = 1\text{ k}\Omega$ , AAF filter on, $I_{PD} 100\text{ }\mu\text{A}$ to $200\text{ }\mu\text{A}$	—	40.8	—	kHz
Current amplification block						
Gain variation to temperature	$dG_{IPDR}$	In playback, $I_{PD} = 60\text{ }\mu\text{A}$ to $240\text{ }\mu\text{A}$ , $T_a = -20^{\circ}\text{C}$ to $+75^{\circ}\text{C}$	-3	—	3	%
	$dG_{IPDW}$	In recording, $I_{PD} = 0.2\text{ mA}$ to $3.2\text{ mA}$ , $T_a = -20^{\circ}\text{C}$ to $+75^{\circ}\text{C}$	-3	—	3	
Gain ratio variation to temperature	$d\frac{G_{IPDR}}{G_{PMW}}$	In playback, $I_{PD} = 60\text{ }\mu\text{A}$ to $240\text{ }\mu\text{A}$ , In recording, $I_{PD} = 0.2\text{ mA}$ to $3.2\text{ mA}$ , $T_a = -20^{\circ}\text{C}$ to $+75^{\circ}\text{C}$	-3	—	3	%
Signal changeover response	$t_{IPDSW1}$	$\times 10 \rightarrow \times 1$ , at having reached $\pm 0.5\%$	—	100	300	ns
	$t_{IPDSW2}$	$\times 1 \rightarrow \times 10$ , at having reached $\pm 0.5\%$	—	200	500	
I to V conversion						
Offset voltage variation to temperature	$\frac{dV_{IVOF}}{dT}$	$VR1 = 0\text{ }\Omega$ , $I_{PD} = 0\text{ }\mu\text{A}$ , $T_a = -20^{\circ}\text{C}$ to $+75^{\circ}\text{C}$	—	10	50	$\frac{\mu\text{V}}{^{\circ}\text{C}}$
Slew rate	$SI_{IV}$		20	34	—	V/ $\mu\text{s}$
Open loop gain	$G_{IV}$		—	50	—	dB
Zero-cross frequency	$f_{0IV}$	Output amplitude at 1 V[p-p]	—	8	—	MHz
Settling time	$t_{IVSET}$	Error $\pm 0.5\%$ , output variation: within the range of 0 V to 2 V	—	100	200	ns
AAF analog SW						
On resistance at playback	$R_{AFR}$	$0\text{ }\Omega$ between $I_{VOUT}$ and $I_{VIN}$	—	175	250	$\Omega$
On resistance at recording	$R_{AFW}$		—	200	300	$\Omega$
DAC1						
f characteristics	$f_{DAC1}$	Sine wave signal equivalent to 40 mA[p-p] of current amplitude at LPF12 pin, DAC7 [0h], DAC8 [Fh], DAC9 [00h], RDCP2 pin = 1 000 pF	—	1	—	MHz

# ■ Electrical Characteristics at $V_{CC} = 5.0\text{ V}$ , $T_a = 25^\circ\text{C}$ (continued)

## • Design reference data (continued)

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
DAC1 (continued)						
Driving current temperature characteristics	Err <sub>DA1</sub>	Including DAC8 when setting at "FFh", DAC7 [0h], DAC8 [Fh], T <sub>a</sub> = 0°C to +75°C	—	7	10	%
Offset current variation to temperature	$\frac{dI_{\text{ION}}}{dT}$	"00h", LPF-on, including DAC7, DAC8, DAC7 [0h], DAC8 [Fh], T <sub>a</sub> = −25°C to +75°C	—	2	10	$\frac{\mu\text{A}}{^{\circ}\text{C}}$
	$\frac{dI_{\text{IOF}}}{dT}$	"00h", LPF-off, including DAC7, DAC8, DAC7 [0h], DAC8 [Fh], T <sub>a</sub> = −25°C to +75°C	—	0.5	10	
DAC9						
f characteristics	f <sub>DAC9</sub>	Sine wave signal equivalent to 40 mA[p-p] of current amplitude at LPF22 pin, DAC7 [Fh], DAC8 [0h], DAC1 [00h], RDCP1 pin = 1 000 pF	—	1	—	MHz
Driving current temperature characteristics	Err <sub>DA9</sub>	Including DAC8 at setting at "1Fh", DAC7 [Fh], DAC8 [0h], T <sub>a</sub> = 0°C ~ +75°C	—	7	10	%
Offset current variation to temperature	$\frac{dI_{\text{9ON}}}{dT}$	"00h", LPF-on, including DAC7, DAC8, DAC7 [Fh], DAC8 [0h], T <sub>a</sub> = −25°C ~ +75°C	—	2	10	$\frac{\mu\text{A}}{^{\circ}\text{C}}$
	$\frac{dI_{\text{9OF}}}{dT}$	"00h", LPF-off, including DAC7, DAC8, DAC7 [Fh], DAC8 [0h], T <sub>a</sub> = −25°C to +75°C	—	0.5	10	
DAC7						
Driving current temperature characteristics	Err <sub>DA7</sub>	DAC7 [Fh], DAC8 [0h], DAC9 [1Fh], DAC1 [00h], T <sub>a</sub> = −20°C to +75°C	0	8	15	%
Offset current temperature characteristics	$\frac{dI_{\text{DA7OF}}}{dT}$	DAC7 [0h], DAC8 [0h], DAC9 [1Fh], DAC1 [00h], T <sub>a</sub> = −20°C to +75°C	—	0.2	10	$\frac{\mu\text{A}}{^{\circ}\text{C}}$
DAC8						
Driving current temperature characteristics	Err <sub>DA8</sub>	DAC8 [Fh], DAC7 [0h], DAC1 [FFh], DAC9 [00h], T <sub>a</sub> = −20°C to +75°C	0	8	15	%
Offset current temperature characteristics	$\frac{dI_{\text{DA8OF}}}{dT}$	DAC8 [0h], DAC7 [0h], DAC1 [FFh], DAC9 [00h], T <sub>a</sub> = −20°C to +75°C	—	0.2	10	$\frac{\mu\text{A}}{^{\circ}\text{C}}$



# ■ Electrical Characteristics at $V_{CC} = 5.0\text{ V}$ , $T_a = 25^\circ\text{C}$ (continued)

## • Design reference data (continued)

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
DAC2						
Offset current temperature characteristics	$\frac{dI_{DA2OF}}{dT}$		—	—	10	$\frac{\mu A}{^{\circ}C}$
Driving current temperature characteristics	Err <sub>DA2</sub>	DAC3 = "FFh", set to DAC4 = "Fh", T <sub>a</sub> = −20°C to +75°C	—	6	10	%
Settling time	t <sub>SDA2A</sub>	XWR ↑ to DAC2 [Δ4: 10 h to 14h], ±0.5 LSB DAC4 [Fh]	—	40	100	ns
	t <sub>SDA2B</sub>	XWR ↑ to DAC2 [Δ7F: 10 h to 8 Fh], ±1.0 LSB DAC4 [Fh]	—	80	200	
DAC3						
Offset current temperature characteristics	$\frac{dI_{DA3OF}}{dT}$		—	—	10	$\frac{\mu A}{^{\circ}C}$
Driving current temperature characteristics	Err <sub>DA3</sub>	DAC3 = "FFh", set to DAC4 = "Fh", T <sub>a</sub> = −20°C to +75°C	—	6	10	%
Settling time	t <sub>SDA3A</sub>	XWR ↑ to DAC3 [Δ4: 10 h to 14h], ±0.5 LSB DAC4 [Fh]	—	40	100	ns
	t <sub>SDA3B</sub>	XWR ↑ to DAC3 [Δ7F: 10 h to 8Fh], ±1.0 LSB DAC4 [Fh]	—	80	200	
DAC4						
Offset current temperature characteristics	$\frac{dI_{DA4OF}}{dT}$		—	—	10	$\frac{\mu A}{^{\circ}C}$
Driving current temperature characteristics	Err <sub>DA4</sub>	DAC4 = "Fh", set to DAC2 = "FFh", T <sub>a</sub> = −20°C to +75°C	—	6	10	%
Supply voltage monitoring block						
Abnormal supply voltage detection hysteresis	V <sub>PSDHYS</sub>	Voltage difference between abnormality detection and release of supply voltage drop, V <sub>PSD1</sub> −V <sub>PSDH</sub>	—	300	—	mV
	V <sub>PSOHYS</sub>	Voltage difference between abnormality detection and release of supply voltage drop, V <sub>PSOH</sub> −V <sub>PSOL</sub>	—	300	—	
Comparator in abnormally emitted light detection block						
Input offset voltage	V <sub>PDCOF</sub>	Insufficiently emitted light detection	−5	—	5	mV
	V <sub>POCOF</sub>	Excessively emitted light detection	−5	—	5	

■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

• Design reference data (continued)

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Comparator in abnormally emitted light detection block (continued)						
Input offset voltage variation to temperature	$\frac{dV_{PDCOF}}{dT}$	Insufficiently emitted light detection	—	—	20	$\frac{\mu V}{^{\circ}C}$
	$\frac{dV_{POCOF}}{dT}$	Excessively emitted light detection	—	—	20	
Abnormally emitted light detection response	$t_{PWDNF}$	Insufficiently emitted light detection	—	150	300	ns
	$t_{PWOVF}$	Excessively emitted light detection	—	150	300	
Abnormally emitted light release response	$t_{PWDR}$	Insufficiently emitted light detection	—	150	300	ns
	$t_{PWOVF}$	Excessively emitted light detection	—	150	300	
DAC5 block						
Offset voltage variation to temperature	$\frac{dV_{DA5OF}}{dT}$	Set to "Fh"	—	−10	80	$\frac{\mu V}{^{\circ}C}$
DAC6 block						
Offset voltage variation to temperature	$\frac{dV_{DA5OF}}{dT}$	Set to "Fh"	—	−10	80	$\frac{\mu V}{^{\circ}C}$
Optical monitor for abnormally emitted light detection						
Offset voltage variation to temperature	$\frac{dV_{EROFR}}{dT}$	In playback, $I_{PD} = 0\text{ }\mu A$	—	−20	210	$\frac{\mu V}{^{\circ}C}$
	$\frac{dV_{EROFW}}{dT}$	In recording, $I_{PD} = 0\text{ }\mu A$	—	−20	200	
Gain variation to temperature	$dG_{ERR1}$	In playback, $I_{PD} = 100\text{ }\mu A$ to $200\text{ }\mu A$ , $T_a = -20^{\circ}C$ to $+75^{\circ}C$	−3	0.5	3	%
	$dG_{ERR2}$	In playback, $I_{PD} = 100\text{ }\mu A$ to $200\text{ }\mu A$ , $T_a = -20^{\circ}C$ to $+75^{\circ}C$	−3	0.5	3	
	$dG_{ERW}$	In recording, $I_{PD} = 100\text{ }\mu A$ to $2\text{ }000\text{ }\mu A$ , $T_a = -20^{\circ}C$ to $+75^{\circ}C$	−3	0.5	3	
Gain ratio variation to temperature	$d\frac{G_{ERR}}{G_{ERW}}$	$T_a = -20^{\circ}C$ to $+75^{\circ}C$	−3	0.5	3	%
Settling time	$t_{ERR}$	In playback, error: $\pm 0.5\%$ , current variation $100\text{ }\mu A$ to $200\text{ }\mu A$	—	250	400	ns
	$t_{ERW}$	In playback, error: $\pm 0.5\%$ , current variation $100\text{ }\mu A$ to $2\text{ }000\text{ }\mu A$	—	100	200	
Signal changeover response ( $\times 10$ mode)	$t_{ERSW1A}$	Playback $\rightarrow$ recording $\pm 0.5\%$ addr "9": D4 = "0" $\times 10$	—	170	400	ns
	$t_{ERSW2A}$	Recording $\rightarrow$ playback $\pm 0.5\%$ addr "9": D4 = "0" $\times 10$	—	550	1 000	

# ■ Electrical Characteristics at $V_{CC} = 5.0\text{ V}$ , $T_a = 25^\circ\text{C}$ (continued)

## • Design reference data (continued)

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Optical monitor for abnormally emitted light detection (continued)						
Signal changeover response × 5 mode	t <sub>ERSW1B</sub>	Playback → recording ±0.5%, addr "9": D4 = "1" × 5	—	200	400	ns
	t <sub>ERSW2B</sub>	Recording → playback ±0.5%, addr "9": D4 = "1" × 5	—	250	500	
Control operation response	Register setting → output					
Data writing to LPF-off	t <sub>87</sub>	XWR ↑ to LPF "off"	—	0.8	2.0	μs
Data writing to LPF-on	t <sub>88</sub>	XWR ↑ to LPF "on"	—	250	600	ns
Data writing to AAF-off	t <sub>85</sub>	XWR ↑ to AAF "off"	—	60	200	ns
Data writing to AAF-on	t <sub>86</sub>	XWR ↑ to AAF "on"	—	20	200	ns
Data writing to DAC6 changeover *3	t <sub>207</sub>	XWR ↑ to DAC6 ±0.5%	—	0.9	2.5	μs
Data writing to DAC5 changeover *3	t <sub>208</sub>	XWR ↑ to DAC5 ±0.5%	—	0.9	2.5	μs
Data writing to shunt on *4	t <sub>89</sub>	XWR ↑ to shunt circuit "on", LDERR register "1"	—	—	430	ns
Data writing to shunt off *4	t <sub>90</sub>	XWR ↑ to shunt circuit "off", LDERR register "0"	—	—	230	ns
Control operation response	Input → output					
RPHOLD ↑ to PWRMONI changeover	t <sub>37</sub>	RPHOLD ↑ to × 1, at having reached ±0.5%	—	0.4	0.9	μs
RPHOLD ↓ to PWRMONI changeover	t <sub>38</sub>	RPHOLD ↓ to × 10, AAF, at having reached ±0.5%	—	0.4	0.9	μs
RPHOLD ↑ to mask signal *5	t <sub>45</sub>	RPHOLD ↑ to mask signal ↓	—	15	30	ns
Mask signal width at RPHOLD ↑ *5	t <sub>46</sub>	Mask signal ↓ to mask signal ↑ at RPHOLD high	—	1	1.1	μs
RPHOLD ↓ to mask signal *5	t <sub>47</sub>	RPHOLD ↓ to mask signal ↓	—	15	30	ns
Mask signal width at RPHOLD ↑ *5	t <sub>48</sub>	Mask signal ↓ to mask signal ↑ at RPHOLD low	—	1	1.1	μs
RPHOLD ↓ to AAFRST signal ↑ *5	t <sub>211</sub>	RPHOLD ↓ to AAFRST ↑	—	15	30	ns
AAFRST signal width *5	t <sub>212</sub>	AAFRST ↑ to AAFRST ↓	—	2	2.2	μs
Shunt circuit "on" *6	t <sub>49</sub>	XCLR ↓ to shunt circuit "on"	—	—	430	ns
Shunt circuit "off" *6	t <sub>50</sub>	XCLR ↑ to shunt circuit "off"	—	—	230	ns

Note) \*3: Measure at DACMONI pin.

\*4: Measuring is impossible outside the IC.

\*5: Measuring is impossible outside the IC.

The values of  $t_{46}$ ,  $t_{48}$  and  $t_{212}$  are determined by the built-in resistor  $R_{in1}$  (10 kΩ, allowance: 10%) and the external C1.

\*6: Measuring is impossible outside the IC. The built-in resistor  $R_{in2}$  (10 kΩ, allowance: 10%) and the external C2.

■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

• Design reference data (continued)

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Control operation response      Input → output (continued)						
AAF reset "reset" *6	$t_{213}$	AAFRST ↑ to AAF "reset"	—	—	200	ns
AAF reset "normal" *6	$t_{214}$	AAFRST ↓ to AAF "normal"	—	—	200	ns
Mask signal (wrt. ERFIL) *7	$t_{215}$	ERFIL ↑ to XLDERR1 ↓	—	1.2	2.0	μs
	$t_{216}$	ERFIL ↓ to XLDERR1 ↑	—	15	—	ns
Register → output						
Mode changeover	$t_{55}$	XWR ↑ to AAFRST test mode	—	25	60	ns
AAFRST	$t_{56}$	XWR ↑ to AAFRST normal mode	—	200	400	
Mode changeover	$t_{57}$	XWR ↑ to SW6 test mode	—	90	200	ns
SW6	$t_{58}$	XWR ↑ to SW6 normal mode	—	60	150	
Mode changeover	$t_{59}$	XWR ↑ to XHFON test mode	—	20	60	ns
XHFON	$t_{60}$	XWR ↑ to XHFON normal mode	—	25	70	
Mode changeover	$t_{61}$	XWR ↑ to SW2 test mode	—	30	80	ns
SW2	$t_{62}$	XWR ↑ to SW2 normal mode	—	20	50	
Mode changeover	$t_{63}$	XWR ↑ to SW3 test mode	—	30	70	ns
SW3	$t_{64}$	XWR ↑ to SW3 normal mode	—	20	50	
Mode changeover	$t_{67}$	XWR ↑ to SW1 test mode	—	20	50	ns
SW1	$t_{68}$	XWR ↑ to SW1 normal mode	—	35	100	
Mode changeover	$t_{69}$	XWR ↑ to LEVSW test mode	—	0.55	2.0	μs
LEVSW	$t_{70}$	XWR ↑ to LEVSW normal mode	—	0.35	1.0	
Test mode operation	$t_{75}$	XWR ↑ to AAF filter reset	—	25	100	ns
AAF filter *8	$t_{76}$	XWR ↑ to AAF filter normal	—	200	400	
Test mode operation	$t_{77}$	XWR ↑ to × 1, when reaching ±0.5%	—	0.4	0.9	μs
Current amplification changeover	$t_{78}$	XWR ↑ to × 10, when reaching AAF ±0.5%	—	0.4	0.9	
Test mode operation	$t_{79}$	XWR ↑ to XHFON ↑	—	20	60	ns
XHFON	$t_{80}$	XWR ↑ to XHFON ↓	—	25	70	
Test mode operation	$t_{81}$	XWR ↑ to SW2 "on" DAC2 ±2.0 LSB	—	90	200	ns
SW2 *9	$t_{81A}$	XWR ↑ to SW2 "on" DAC2 × 50%	—	30	80	
	$t_{82}$	XWR ↑ to SW2 "off" 0 mA ±2.0 LSB	—	50	150	
	$t_{82A}$	XWR ↑ to SW2 "on" DAC2 × 50%	—	20	60	

Note) \*6: Measuring is impossible outside the IC. The built-in resistor  $R_{in2}$  (10 kΩ, allowance: 10%) and the external C2.

\*7: Measuring is impossible outside the IC.

\*8: No external fitting until on/off of switch.

\*9: Set the data to "7Fh".

■ Electrical Characteristics at  $V_{CC} = 5.0\text{ V}$ ,  $T_a = 25^\circ\text{C}$  (continued)

• Design reference data (continued)

Note) The characteristics listed below are theoretical values based on the IC design and are not guaranteed.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Register → output (continued)						
Test mode operation SW3 *9	$t_{83}$	XWR ↑ to SW3 "on" DAC3 $\pm 2.0$ LSB	—	330	600	ns
	$t_{83A}$	XWR ↑ to SW3 "on" DAC3 $\times 50\%$	—	30	80	
	$t_{84}$	XWR ↑ to SW3 "off" 0 mA $\pm 2.0$ LSB	—	50	150	
	$t_{84A}$	XWR ↑ to SW3 "on" DAC3 $\times 50\%$	—	20	60	
Test mode operation SW1 *10	$t_{91}$	XWR ↑ to SW1 "off"	—	20	100	ns
	$t_{92}$	XWR ↑ to SW1 "on"	—	35	150	
Test mode operation DAC5	$t_{93}$	XWR ↑ to DAC5 W, at having reached $\pm 0.5$ LSB	—	1.0	2.5	$\mu\text{s}$
	$t_{94}$	XWR ↑ to DAC5 R, at having reached $\pm 0.5$ LSB	—	0.7	2.5	
Test mode operation DAC6	$t_{95}$	XWR ↑ to DAC6 W, at having reached $\pm 0.5$ LSB	—	1.0	2.5	$\mu\text{s}$
	$t_{96}$	XWR ↑ to DAC6 R, at having reached $\pm 0.5$ LSB	—	0.7	2.5	

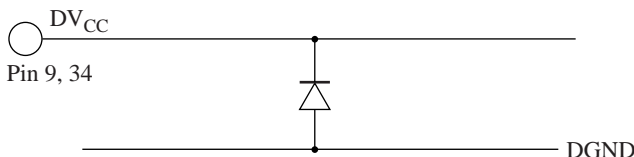
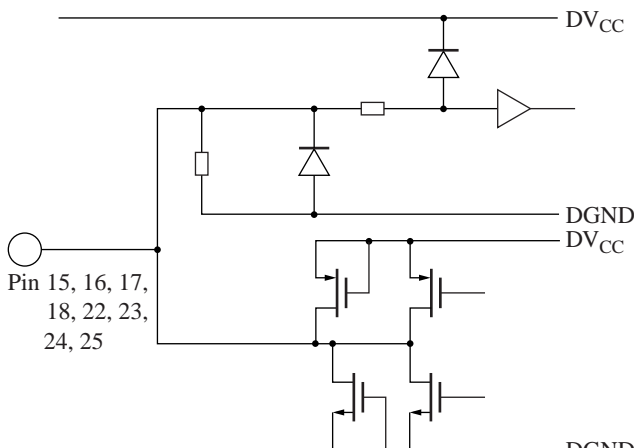
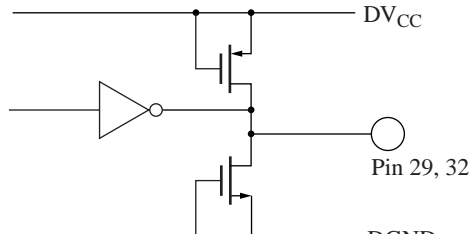
Note) \*9 : Data sets up "7Fh".

\*10: DAC1 = 7 Fh, DAC9 = 00 h, DAC7 = 0h, DAC8 = Fh

■ Terminal Equivalent Circuits

Pin No.	Symbol	Equivalent circuit
1 2 3	Pin 1: SGND Pin 2: DGND Pin 3: DGND	—
4 5 6	Pin 4: PKMD Pin 5: BIMD Pin 6: RPHOLD	
7 8	Pin 7: XWR Pin 8: XRD	

# ■ Terminal Equivalent Circuits (continued)

Pin No.	Symbol	Equivalent circuit
9	DV <sub>CC</sub>	
10	DGND	—
11	Pin 11: AD0	Refer to pin 4
12	Pin 12: AD1	
13	Pin 13: AD2	
14	Pin 14: AD3	
15	Pin 15: DT0	
16	Pin 16: DT1	
17	Pin 17: DT2	
18	Pin 18: DT3	
19	Pin 19: DGND	—
20	Pin 20: SGND	
21	Pin 21: SGND	
22	Pin 22: DT4	Refer to pin 15
23	Pin 23: DT5	
24	Pin 24: DT6	
25	Pin 25: DT7	
26	XLDEN	Refer to pin 7
27	XCLR	Refer to pin 4
28	DGND	—
29	XLDERR	

# ■ Terminal Equivalent Circuits (continued)

Pin No.	Symbol	Equivalent circuit
30 31	Pin 30: PWMSK Pin 31: ERFIL	
32	XHFON	Refer to pin 29
33	DGND	—
34	DV <sub>CC</sub>	Refer to pin 9
35	AGND	—
36	VC	
37	RREF	
38	LPF11	

# ■ Terminal Equivalent Circuits (continued)

Pin No.	Symbol	Equivalent circuit
39	LPF12	
40	Pim 40: IGND	—
41	Pim 41: SGND	
42	Pim 42: SGND	
43	LPF91	Refer to pin 38
44	LPF92	Refer to pin 39
45	AV <sub>CC</sub>	
46	DETMONI	
47	PWRMONI	



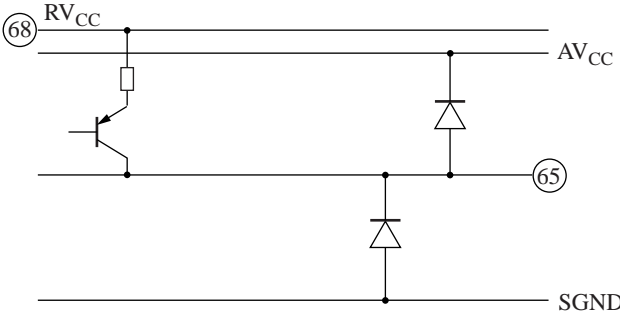
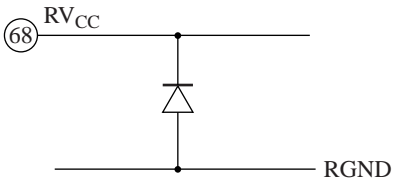
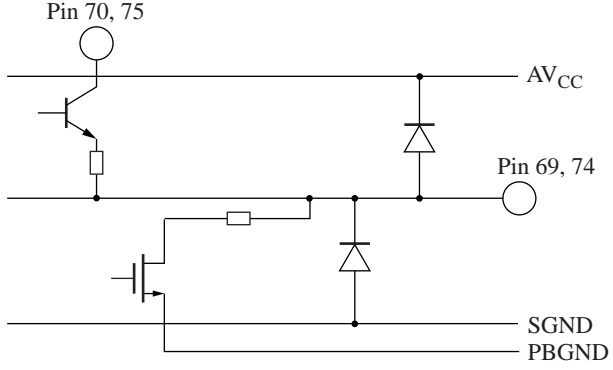
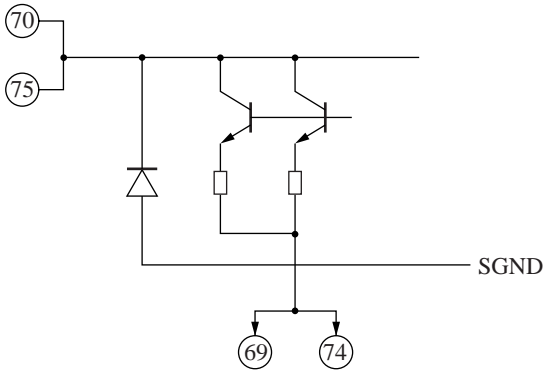
■ Terminal Equivalent Circuits (continued)

Pin No.	Symbol	Equivalent circuit
48	AAF	
49	IVOUT	
50	IVIN	
51	IPD	
52	CGND	—

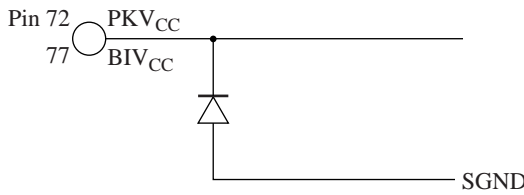
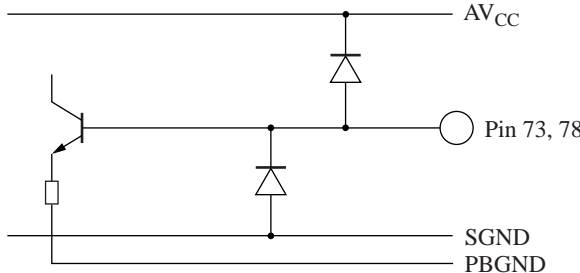
# ■ Terminal Equivalent Circuits (continued)

Pin No.	Symbol	Equivalent circuit
53	$CV_{CC}$	
54	AGND	—
55 56	Pim 55: ERREF Pim 56: VNR	
57	DACMONI	
58	$AV_{CC}$	Refer to pin 45
59 60 61 62	Pim 59: SGND Pim 60: SGND Pim 61: SGND Pim 62: RGND	—
63 64	Pim 63: RDCP1 Pim 64: RDCP2	

■ Terminal Equivalent Circuits (continued)

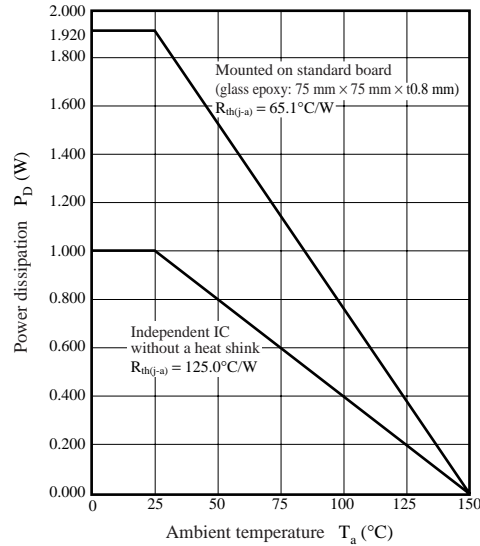
Pin No.	Symbol	Equivalent circuit
65	LDRP	
66	N.C.	—
67	N.C.	—
68	RV <sub>CC</sub>	
69	LDPK	
70	XLDPK	

■ Terminal Equivalent Circuits (continued)

Pin No.	Symbol	Equivalent circuit
71	PKGND	—
72	PKV <sub>CC</sub>	
73	PKDCP	
74	LDBI	Refer to pin 69
75	XLDBI	Refer to pin 70
76	BIGND	—
77	BIV <sub>CC</sub>	Refer to pin 72
78	BIDCP	Refer to pin 73
79	SGND	—
80	SGND	—

■ Application Notes

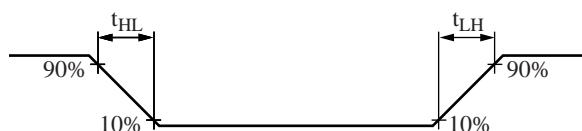
1.  $P_D$  —  $T_a$  curves of QFP080-P-1212



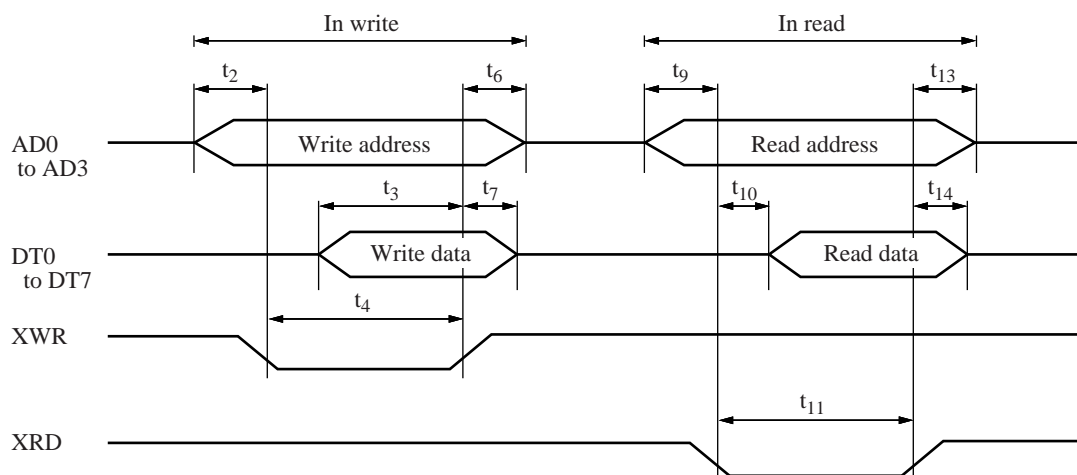
## ■ Application Notes (continued)

### 2. Timing chart

#### 1) Definition of rising and falling



#### 2) Interface



Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Switching characteristics	$t_{LH}$	10% to 90%	—	—	10	ns
	$t_{HL}$	90% to 10%	—	—	10	
Pulse width	$t_4$	XWR ↓ to XWR ↑	50	—	—	ns
	$t_{11}$	XRD ↓ to XRD ↑	70	—	—	
Setup time	$t_2$	AD defined to XWR ↓	10	—	—	ns
	$t_3$	DT defined to XWR ↑	35	—	—	
	$t_9$	AD defined to XRD ↓	10	—	—	
	$t_{10}$	XRD ↓ to DT defined	—	—	50	
Hold time	$t_6$	XWR ↑ to AD released	0	—	—	ns
	$t_7$	XWR ↑ to DT released	0	—	—	
	$t_{13}$	XRD ↑ to AD released	0	—	—	
	$t_{14}$	XRD ↑ to DT released	0	—	30	

**■ Application Notes (continued)****3. I/O specifications****• Parallel interface**

- 1) I/O level is CMOS.
- 2) Transfers a digital signal to DAC and each mode setting register with 4 addresses, 8 data and 2 control signals.

Address signal      AD0 to AD3

Data signal          DT0 to DT7

Control signal      XWR, XRD

- 3) Write can be done at the rise of XWR.

However, selection of a write register can be done at the fall of XWR.

DAC and register data are stored at D-FF.

- 4) Read appears on DT0 to DT7 at XRD = low.
- 5) Refer to "■ Application Notes, 2. Timing chart" for the timing chart.
- 6) Each signal line is pulled up and down as below:

Pull-down to GND with 100 k $\Omega$       AD0 to AD3

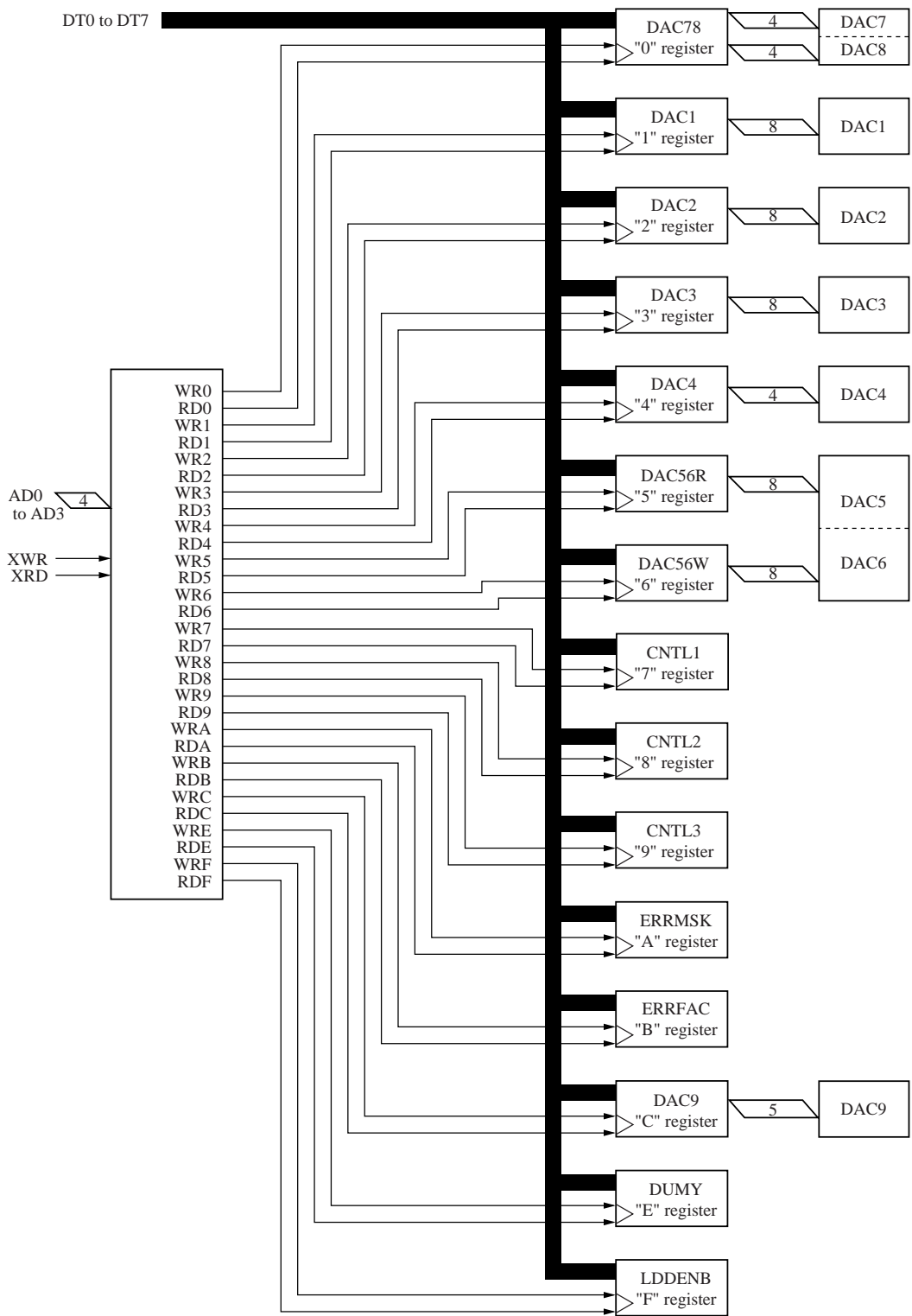
DT0 to DT7

Pull-up to V<sub>CC</sub> with 100 k $\Omega$       XWR

WRD

■ Application Notes (continued)

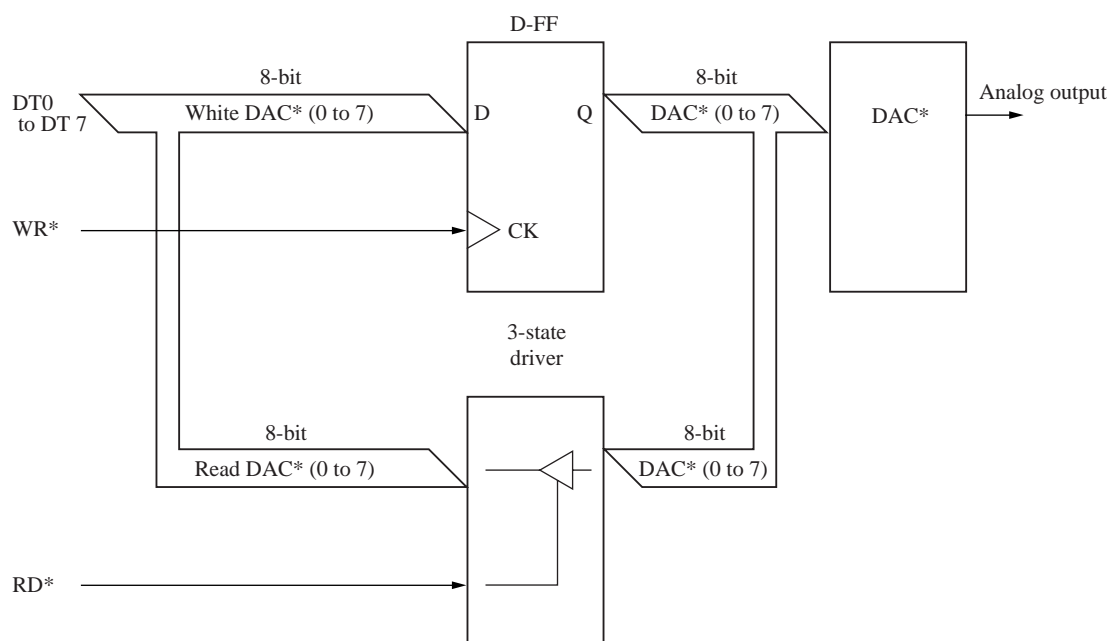
4. Signal flow



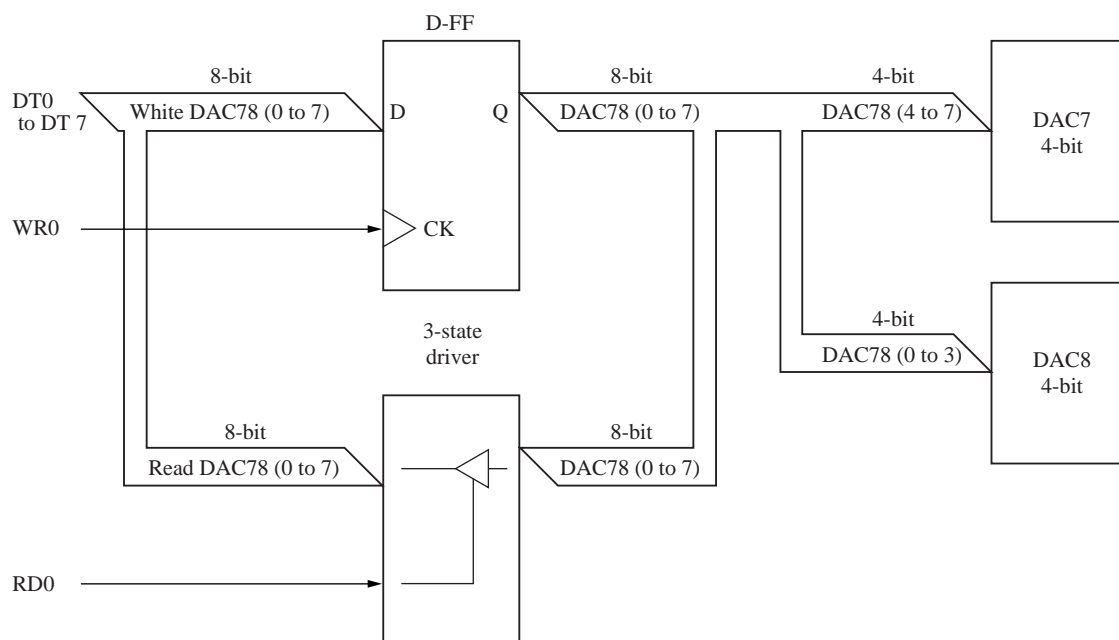
## ■ Application Notes (continued)

### 5. Register circuit configuration

#### 1) DAC1, DAC2, DAC3, DAC4, DAC9



#### 2) DAC7, DAC8

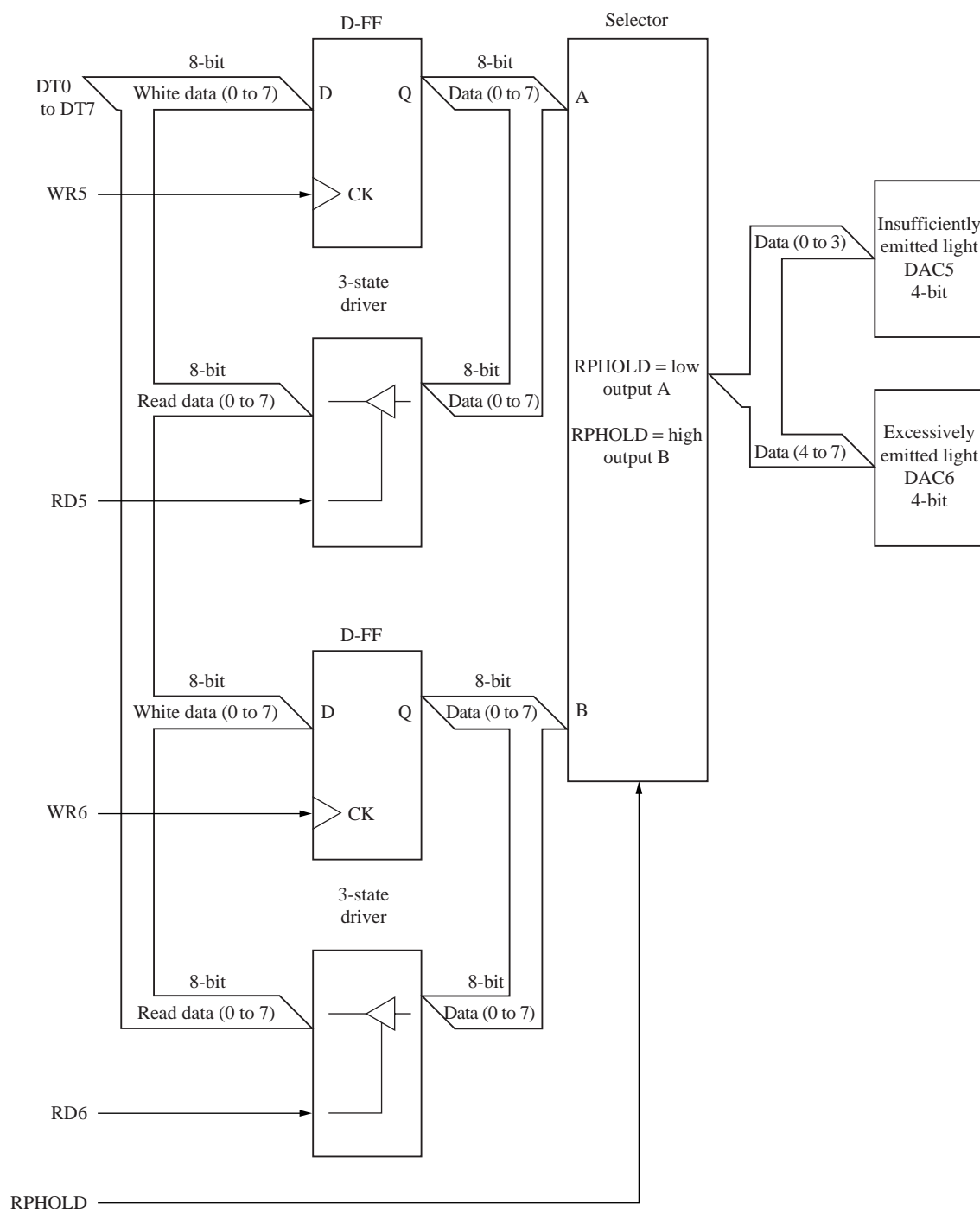




# ■ Application Notes (continued)

## 5. Register circuit configuration (continued)

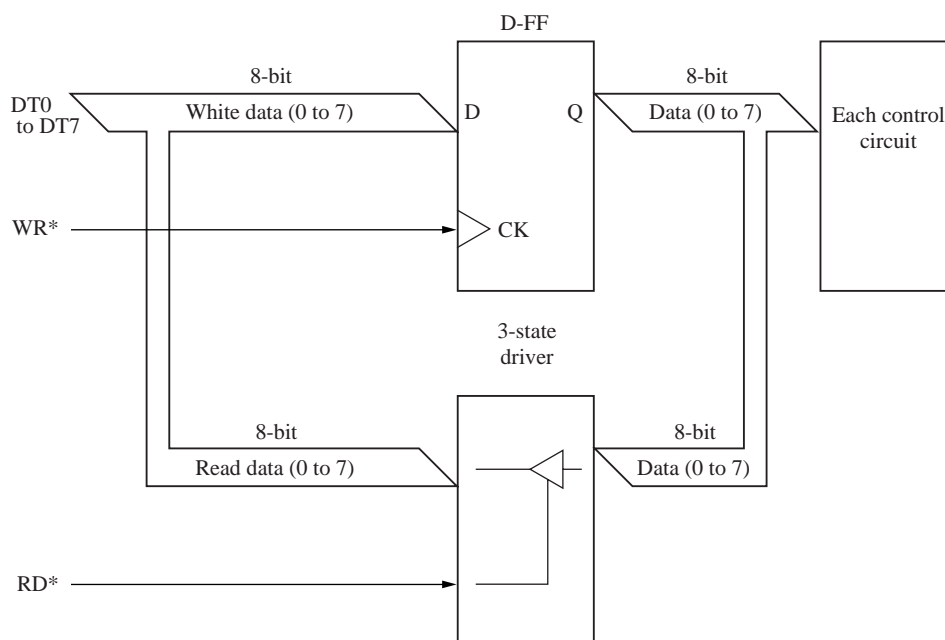
### 3) DAC56R, DAC56W



## ■ Application Notes (continued)

### 5. Register circuit configuration (continued)

4) CNTL1, CNTL2, CNTL3, ERRMSK, ERRFAC, DUMY, LDDENB





# ■ Application Circuit Example (continued)

## • Resistance and capacitance

Symbol	Resistor value	Unit
R1	10	k $\Omega$
R2	—	—
R3	—	—
R4	—	—
R5	1	k $\Omega$
R6	10	k $\Omega$
R7	82	$\Omega$
R8	10	k $\Omega$
R9	82	$\Omega$
R10	3	$\Omega$
R11	3	$\Omega$
(Rin1)	10	k $\Omega$
(Rin2)	10	k $\Omega$

Symbol	Resistor value	Unit
C1	220	pF
C2	100	pF
C3	0.1	$\mu$ F
C4	0.01	$\mu$ F
C5	—	—
C6	—	—
C7	0.1	$\mu$ F
C8	—	—
C9	18	pF
C10	0.1	$\mu$ F
C11	0.1	$\mu$ F
C12	5 600	pF
C13	5 600	pF
C14	0.1	$\mu$ F
C15	0.1	$\mu$ F
C16	1	$\mu$ F
C17	0.1	$\mu$ F
C18	1	$\mu$ F
C19	0.1	$\mu$ F